2022

An Educational Intervention on Occupational Radiation Exposure and Risk of Cataract Development

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An Educational Intervention on Occupational Radiation Exposure and Risk of Cataract Development

A DNP Project Presented to the Faculty of the
Nicole Wertheim College of Nursing and Health Sciences

Department of Nurse Anesthesia, Florida International University

In partial fulfillment of the requirements for the degree of
Doctor of Nursing Practice

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Date: 11/29/2022

TABLE OF CONTENTS

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Abstract

Background: Anesthesia providers are increasingly practicing under radiography and fluoroscopically guided procedures in surgical suites without the conventional tools present in standard operating rooms. During these cases, physicians, nurses, and anesthesia providers are inadvertently exposed to radiation. Radiation has inherent risks; studies have demonstrated exposure to low levels of medical radiation can increase the risk of several types of cancer, bone marrow suppression, infertility, birth deformities, and cataracts. Unlike the standard procedure for surgeons and interventionalists, who routinely use leaded glasses or ceiling-mounted lead shields to protect the eyes, there are currently no similar protections for anesthesia providers, who may be unintentionally leaving themselves exposed and at higher risk for radiation-induced cataracts.

Objectives: The purpose of this quality improvement (QI) project is to improve anesthesia knowledge of radiation hazards within the workplace and steps to mitigate risk. The QI project aims to educate anesthetists about radiation-induced cataracts and protective measures.

Methods: The primary methodology of the proposed quality improvement project is to administer an educational intervention to anesthesia providers which discusses occupational radiation exposure and cataract development. Pre-assessment and post-assessment surveys will be used to measure the effectiveness of the educational intervention.

Results: Overall, there was an improvement in anesthesia provider knowledge following the educational intervention. Participants also answered they would “most likely” consider using additional PPE and leaded glasses to limit occupational exposure compared to “somewhat likely” before the educational intervention.

Keywords: Radiation exposure and anesthesia providers, radiation safety for anesthesia providers, radiation and cataract, eye lens radiation exposure, radiation-induced cataracts.

Problem Identification

As medicine and technology evolve, the complexity of medical management does too. Medical specialties, specifically anesthesia is increasingly practiced under fluoroscopically guided procedures in surgical suites without the conventional tools present in standard operating rooms [1.] Anesthetists are inadvertently exposed to radiation due to the frequent use of radiography, fluoroscopy, and computed tomography in the intraoperative area[2]. During these cases, physicians, nurses, and anesthesia providers are inadvertently exposed to radiation. Low-level radiation exposure increases the risk of infertility and birth defects, bone marrow suppression, thyroid carcinoma, and cataract formation [9]. A study conducted by Anastasian, Strozyk, Meyers, Wang, & Berman found radiation exposure to the anesthesiologist's face was 6x greater in neurointerventional procedures than that of the radiologist.[7] This demonstrates the implications of radiation protection to the anesthesia provider.

One of the most radiosensitive tissues in the body is the ocular lens, which, when exposed has been proven to cause cataracts. Eye lens injuries can occur to the interventional and other radiology employees if appropriate radiation safeguards are not maintained[4]. The data correlating exposure to ionizing radiation with an increased incidence of cataracts is substantial[5].

Although radiation-induced cataracts have been known, it was not until 2009 that cataract development due to chronic low-dose exposure was reported in radiology staff who performed continuous fluoroscopy[6]. Studies have demonstrated average radiation exposure to anesthesia providers doubles after staffing an electrophysiology laboratory[2]. Additional studies have demonstrated the radiation dose to the anesthesia provider's eye can be greater than 3x the interventionalist. Most of the radiation dose to personnel within radiology suites results from scattered x-rays that are reflected from the patient[7].

Technological advancement and the increased reliance on the use of radiological procedures within neurology, cardiology, and urology, evidence suggests interventional personnel can develop cataracts with inadequate radiation protection[3]. Anesthetists and radiologists both wear lead aprons and thyroid shields to protect their bodies from the neck down. Interventional radiologists wear leaded glasses and use lead shields to protect the face. Unlike the standard procedure for surgeons and interventionalists, who routinely use leaded glasses or ceiling-mounted lead shields to protect the eyes, there are currently no similar protections for anesthesia providers, who may inadvertently leave themselves exposed[8]. This project aims to improve the knowledge, attitudes, and perception of anesthesia providers and radiation safety. The knowledge gained could ultimately reduce occupational exposure to radiation while decreasing the incidence of radiation-induced cataracts.

Background

Radiation has inherent risks; studies have demonstrated that exposure to low levels of medical radiation can increase the risk of several types of cancer, bone marrow suppression, infertility, birth deformities, and cataracts. The threshold dose differs across radiation procedures, and the amount of injury is related to the cumulative dose, known as a deterministic effect[9,7]. As the number of interventional procedures grows, radiology staff are predisposed to increased radiation exposure, and these providers are known to receive the highest doses of radiation to the ocular lens[10].

Due to its radiosensitivity, if exposed to ionizing radiation, the eye can develop a radiation-induced cataract from an early age. It has recently been discovered the ocular lens is more sensitive to radiation than previously thought.[10] The International Commission on Radiological Protection (IRCP) recently reduced the occupational lens dose limit substantially, from 150 mSv per year to 20 mSv per year, with no annual exposure >50 mSv. These new guidelines stress the importance of evaluating the dose exposure to all medical workers during radiological procedures[11].

Multiple epidemiologic studies examining occupational radiation exposure and healthcare professionals have confirmed the incidence of radiation-induced cataracts amongst providers[12]. Scattered radiation contact with the anesthetist's eyes can be 3x that of the radiologist within interventional procedures. As the eye tissue is highly radiosensitive, the degree of exposure and risk of cataracts is directly proportional to the level of eye protection. Shielding modalities such as lead curtains and eyewear minimize ocular radiation exposure[2].

Scope of the Problem

Interventional radiology procedures and fluoroscopy can produce moderately high exposure to the unprotected eye as an effect of scatter radiation. Procedures considered high-dose radiation risk include embolization of aneurysms and arteriovenous malformations[7]. Studies reviewing endovascular abdominal aneurysm repairs (EVAR) have demonstrated a dosimeter located on the anesthesia machine receives 15x the dose of radiation than the circulating nurse[2]. Procedures such as endoscopic retrograde cholangiopancreatography (ERCP) and bronchoscopies have also increased radiation exposure to the anesthesia provider by more than 3x the interventionalist. The radiation dose of the provider directly correlates with the amount of care the patient requires. Each intervention from the anesthetist (boluses, infusion changes) increases their radiation exposure by 0.42 Sv. [7]

High exposures occur during many conscious sedation/ monitored anesthesia care procedures. When the anesthesia provider works in the close vicinity of the patient during periods of apnea or hemodynamic instability, the protection from the ceiling shield fails. Another consideration is the position of the provider of the radiation source. During neurovascular procedures, the anesthesia provider works close to the primary field, accounting for higher dose values for ocular radiation exposure- four times higher during EVAR procedures[13,8].

The layout of the interventional procedure suite, the fluoroscopy system, and the positioning of the anesthesia equipment can significantly contribute to the anesthesiologists' degree of radiation exposure[7]. The positioning of the anesthetist on the same side of the table as the radiograph tube exposes the provider to more scatter radiation than the interventionalist, who is working on the opposite side. Ergonomic factors often govern room arrangement; access to the patient, equipment, and room to care for the patient by two clinicians[7]. New interventional rooms should allow the anesthetist to work beside the radiologist or at the head of the bed in areas with lower exposure rates[5].

Consequences of the Problem

Studies have demonstrated anesthesia personnel working in cardiac catheterization accumulate the equivalent of 1.3–1.8 mSv per month. According to current radiation standards, exposure to that level may pose a threat to cataract development [7.] A study conducted by Vano demonstrated 41 % of nurses and technicians and 50% of interventional cardiologists with subcapsular lens changes characteristic of ionizing radiation exposure compared with 10 % in the control group[1]. Data indicates eye lens doses to occupational exposure, such as interventional radiologists and cardiologists, frequently exceed the annual threshold of 20mSv[14]. Radiologists who use lead glasses and aprons demonstrated a reduced cataract risk than those who did not wear eye protection[15].

Reviews have established a strong correlation between ionizing radiation and eye lens opacities/cataracts, with a lower threshold than previously believed. [16] The current IRCP standard of equivalent dose limit for ocular lens radiation of 20 mSv per year may be 10-fold lower[2,7]. Miller, Schueler, and Balter extrapolated data from populations exposed to low doses of radiation, implying lens opacities may appear at exposures considerably lower than 2 Gy [17].

Knowledge Gaps

While most research regarding occupational exposure to radiation-causing cataracts is focused on the interventionalist or radiology technician, few studies have specifically been anesthesia focused. Medical professionals have been aware of the effects of radiation-produced mutations for many years, however, thyroid cancer and cataracts have developed as issues of alarm only in the last decade. Thyroid cancer has emerged as the most studied sequelae, and less significance has been given to radiation-induced cataracts.[9]

A survey by Khamtuikrua & Suksompong revealed that 78.5% of anesthesia providers routinely use a thyroid shield, but only 31.3% of them wore lead goggles when working with radiation [9]. Studies continue to report a high percentage of anesthetists and surgical specialists with insufficient understanding of radiation hazards/risks. These results highlight the need for education and attention to hazards among these professions[9]. Low compliance rates with lead eyewear can be attributed to the inadequate supply of lead goggles in radiology settings when compared to other equipment like aprons and thyroid shields. Radiology employees should be educated on the adverse consequences of radiation exposure. Staff needs to be encouraged to consistently wear lead goggles and practice radiation protection while increasing the accessibility of goggles in the radiology suite[9].

Objectives

Anesthetists are regularly exposed to radiation while caring for patients; inside the operating room and outside in remote locations where anesthesia is given. There is an increased concern about personal, and occupational radiation exposure. While lead garments adequately shield the trunk, the eye lens is at risk of unprotected exposure. The mechanism of injury is believed to be a combination of both deterministic and stochastic sources, which can induce early cataract[18].

Studies have indicated radiology staff possesses insufficient knowledge about radiation protection [7,9,13,15,19]. Anesthesia and surgical personnel would benefit from detailed radiation protection, education including an understanding of the risks, radiation protection, and the inverse square principle; the farther the distance from the source of radiation, the less exposure risk.[6,2] To reduce occupational eye lens dose absorption, three factors should be practiced; time, distance, and shielding[19]. The anesthesia provider also needs to be mindful of whether the fluoroscopy beam is on or off when providing patient care[5].

Research has shown chronic low levels of radiation exposure increase the risk of eye opacities/cataracts with no clear threshold level. This result challenges the ICRP's threshold dose for the ocular lens[15]. If the scattered radiation exposure to the anesthesia provider is 3x that for the radiologist, anesthetists who regularly work in high-volume environments with frequent fluoroscopic procedures need to wear leaded eye protection. Lead lenses drastically reduce lens radiation exposure, decreasing ionizing radiation by 70-89%[15]. Personal protective equipment such as good-fitting lead glasses and lead/acrylic ceiling screens should be used routinely to decrease eye exposure[20]. Various methods of shielding provide additive security, and the use of multiple modalities (shields, aprons, eyewear, drapes) will minimize exposure[9].

PICO Question

Population (P): Anesthesia providers

Intervention (I): radiation safety educational module

Comparison (C): current practice

Outcomes (O): Improved provider knowledge of radiation safety practices, lead glasses

Methodology

Studies considered in this literature review were selected based on inclusion and exclusion criteria to demonstrate the subject. Inclusion criteria included articles published within the last ten years, written in English, and available in full text. Exclusion criteria included studies with subjects with cataract risk factors such as hypertension, hypercholesteremia, diabetes, previous myocardial infarction, and smoking. The search focused on radiation exposure to the anesthesia provider, specifically radiation-induced cataracts. Databases were accessed through Florida International University (FIU) library services.

Based on the clinical scenario, the following keywords and subject headings were utilized using the appropriate search symbols: Radiation exposure and anesthesia providers, radiation safety for anesthesia providers, radiation and cataract, eye lens radiation exposure, and radiation-induced cataracts. The databases utilized for the search included PubMed, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Google Scholar. The criteria were further delineated by Johns Hopkins Nursing Evidence-Based Practice evidence level and quality guide. A total of ten studies were selected for this literature review.

Review of Literature

Current Practice

Although radiologists and anesthesia providers wear lead aprons and thyroid shields to protect their bodies from the neck down, the standard of practice for interventionalists and surgeons includes a ceiling-mounted lead shield to protect the face and the use of lead glasses.[7] There are currently no similar standards regarding eye protection for anesthesia providers during radiology, and anesthetists may be unaware they are leaving themselves partially unprotected[7,8]. Evidence has shown radiation exposure during fluoroscopy may well exceed the IRCP's threshold for eye injury.[8] The exposure to the anesthesia provider can be as high as the dose reaching the radiologist, especially during interventional procedures[7].

Medical professionals have been knowledgeable of radiation-induced cell mutations for many decades, however, radiation-induced thyroid carcinoma and cataracts have developed as topics of alarm only in the past ten years[9]. Most research has focused on thyroid cancer, and less significance has been given to radiation-induced cataracts. This is why standard protective gear includes routine use of thyroid shields and not eye protection[9]. A study by Khamtuikrua & Suksompong found a low compliance rate with radiation protection amongst anesthesia personnel, 78.5% of the participants wore a thyroid shield, but only 31.3% wore lead goggles[9]. A similar finding was discussed in a study by Lian, Xiao, Ji, et al, with only 60% of radiology employees using both lead aprons and glasses[15].

Evidence suggests cataract development as a stochastic effect without a known threshold limit, and this emphasizes the importance of radiation protection of the entire room[18]. All radiology staff should be educated and encouraged to use eye protection in addition to the standard measures. A contributing factor to the low rate of compliance is the limited availability of lead goggles in the workplace in comparison to other PPE[9]. Lead goggles should be increasingly made available in the workplace and become the new standard of defense[9]. Anesthesia providers may also use moveable lead curtains/walls in addition to goggles as an extra measure to reduce exposure[18].

Study Characteristics

Radiology/Fluoroscopy

The 10 studies in this literature review all correlated occupational radiation exposure to interventional procedures that use angiography or fluoroscopy[4,7,8,10,11,13,18,19]. Each study utilized a dosimeter specifically designed to measure eye-lens dose[4]. Dosimeter absorption was assumed to represent ocular lens radiation exposure[8]. The dosimeters were worn on the temple, positioned on the side of the head with the highest exposure[10]. Various types of procedures were the focus of each study, and the comprehensive results indicate the highest risk of radiation is in neuroembolization and endovascular aneurysm repairs (EVAR)[13,8,7].

During neuroradiology procedures such as embolization or aneurysm coiling, the anesthesia provider is exposed to more radiation than the surgeon. Due to the nature of the surgery, the anesthetist is positioned close to the patient; often required in hemodynamically unstable patients and when apnea pauses are required throughout the surgery.[13] The protection from the ceiling shield fails in these situations. The radiation exposure of the anesthesia provider during neurologic procedures can be estimated by the number of patient interventions required; estimated by the number of infusion changes made throughout the procedure[7]. EVAR procedures also pose a great risk, a study by Arii, Uchino, Kubo, Kiyama, & Uezono found dosimeter absorption was 4x higher in anesthesia providers than radiologists during EVAR procedures[8]. The greater total dose is assumed to be correlated to the number of ventilation pauses required intraprocedural, which is essential to enable a fluoroscopic view to the radiologist/surgeon[8].

Additional interventions posing a slightly smaller occupational exposure risk include electrophysiology; ablations, endovascular aortic repairs, peripheral vascular procedures, vertebroplasty, kyphoplasty, bronchoscopy, and CT guided/ fluoroscopy-guided procedures [11,13,18,19]. It is prudent that healthcare professionals understand the hazards associated with specific surgeries and identify which situations pose the highest radiation risk[19]. The eye dose in all the procedures mentioned may exceed the IRCP's regulatory annual dose limit. Therefore, it is recommended that all staff members wear leaded glasses during these procedures[11].

ICRP level

The literature review demonstrated various studies with the same conclusion; interventional radiologists, cardiologists, and employees working with high-volume radiology procedures are likely to exceed the ICRP's annual limit of 20mSv or lifetime limit of 500mSv. Above the threshold dose causes eye lens damage and cataract formation without adequate eye protection[4,10]In a study conducted by Merrachi, Bouchard-Bellavance, Perreault, et al, the maximum radiation dose according to ICRP standards would have been surpassed in 5 of 7 cardiologists had they not worn lead glasses[4]. The estimated single-eye lens dose equivalent in a cardiology procedure is as high as 82mSv[10]. This evidence demonstrates the annual ICRP's dose limit is easily exceeded if the protection environment is not adequately structured[19]. To reduce occupational exposure, it is now recommended that all staff, specifically anesthesia providers, wear leaded glasses[11].

Knowledge Deficit

The patient is the source of scattered radiation, which can be 3x higher to the anesthesia provider than the radiologist[7]. Occupational lens dose reduction is contingent upon three factors: time, distance, and shielding [7,19]. Anesthesia providers can greatly reduce their exposure time by maximizing the distance from the patient[7]. There are practical limits to this practice, as creating distance may increase dead space within intravenous tubing and displace the ventilator even farther from the patient's airway[7.]

The literature review also revealed a commonality of insufficient knowledge of radiation hazards amongst anesthesia personnel and surgical specialists[9,13,19]. These findings highlight the need for education on the use of personal protection equipment [9,19]. A thorough training establishing the implications of radiation exposure is essential for all medical professionals who work with ionized radiation[13].

Discussion

Multiple studies within this literature review have found eye lens exposure can be substantially reduced if lead glasses and ceiling shields are used properly[7,9,13,15,19]. The use of lead glasses is associated with reduced cataract risk [15]. It is estimated the use of lead glasses provides 98% or greater radiation reduction[7,13,15]. Leaded eyewear allows for the necessary movement required for patient care[7.] Thus, anesthesia providers who spend a significant amount of time in fluoroscopy should routinely wear leaded glasses as standard PPE [7, 8,13]. This would elevate the practice of radiation safety to that of interventional radiologists[7]

Anesthesia providers must remain aware of occupational exposure risk and take the appropriate measures to minimize this[8]. The three general principles of radiation protection as proposed by the ICRP include: limiting dose exposure, maximizing distance from the source, and using/wearing protective shielding[8,9]. Education and training about radiation hazards and appropriate PPE are critical for healthcare professionals in these environments.

DNP Quality Improvement Project Goal

Anesthesia is increasingly being given under fluoroscopically guided procedures in surgical suites without the conventional tools that exist in standard operating rooms [1.] Anesthetists may be inadvertently exposed to radiation due to the frequent use of radiography, fluoroscopy, and computed tomography in the intraoperative area[2]. Cardiology, orthopedic surgery, urology, vascular surgery, neurology, pulmonology, and gastroenterology are all potential areas of occupational radiation exposure[1,20]. A study by Wang et al., (2017) found the average radiation exposure in an anesthesia department doubled after staffing an electrophysiology laboratory[2]. In a typical interventional procedure, the radiation dose to the eye may exceed current thresholds for tissue reactions if adequate shielding or radiology protection is not practiced [1,17].

Exposure to radiation during interventional medical procedures poses a great risk for ocular exposure throughout a career for the anesthesthetist[3]. The eye is the most radiosensitive tissue in the body, and it has been proven that the earliest sign of radiation-associated damage is cataracts. Eye lens opacification and damage can occur to the interventionalist and other radiology employees if appropriate radiation safeguards are not maintained[4].

New research has indicated a correlation between cataract development in populations exposed to doses of ionizing radiation well below the ICRP's current threshold limits. This may indicate the absence of a threshold dose, or if one does exist, it is very low [1,3,17]. Data amongst radiologic technicians, atomic bomb survivors, and Chernobyl victims who are all exposed to low doses of chronic radiation have concluded that there is a strong association between exposure to ionizing radiation and the development of various cataracts [6,16]. These findings indicate the possibility of a non-threshold (stochastic) response for cataract risk[16]. The ICRP acknowledges cataract formation as stochastic rather than a deterministic effect. This has significant implications, meaning even small amounts of radiation to the eye may result in cataract development[13,15].

Current policies require surgeons and interventionalists wear lead aprons, thyroid shields, and leaded eyewear[13]. Whereas the anesthesia provider is adequately protected at the trunk with a lead apron and thyroid shield, the eye lens remains at risk of unprotected exposure[18]. There are no standards for eye protection, and the anesthetist and many providers may be inadvertently exposing themselves[7,8]. Evidence has shown radiation exposure to the anesthesia provider during fluoroscopy can be as high or higher than the dose absorbed by the radiologist[7,8]. This signifies the importance of proper eye protection[17].

It is recommended that anesthesia practitioners elevate their personal protective equipment to that of the interventionalist and wear leaded glasses[5]. Leaded glasses are estimated to provide a 98% reduction in absorbed ocular dose but do not protect against scatter exposure[2]. Various modes of shielding provide additional protection, and when used properly, ceiling shields and drapes are extremely effective [2,17]. These protective tools are advised for all ancillary staff working in radiology, cardiology, and using fluoroscopy outside of the imaging suite[20].

Goals and Outcomes

The goals and outcomes of this project were developed using the SMART model. The objectives should be specific, measurable, achievable, relevant, and timely.

Specific

Anesthesia providers will participate in an evidence-based educational module discussing the dangers of ionized radiation to the eye, personal protective equipment, and ways to mitigate exposure.

Measurable

The effectiveness of the educational module will be determined through the analysis of a survey that will be provided to the participants in the study. Outcomes will be evaluated based on the pre-and post-test questionnaire, knowledge of radiation hazards, use of leaded glasses, and the significance of occupational radiation exposure. Qualtrics software will be used to create the surveys and analyze data points.

Achievable

Anesthesia providers will be educated and informed on the risks of ionizing radiation and ocular lens and will collaborate in elevating radiation protection standards to include leaded glasses in known areas with high radiation exposure.

Realistic

Anesthesia providers will be educated on radiation exposure, and cataract development by the student registered nurse anesthetist (SRNA). A PowerPoint presentation will be given, and a pre and post-test questionnaire.

Timely

The educational module will be developed over a 6- month time frame. The outcome of this initiative: Within a 6 -month timeframe, anesthesia providers will have an enhanced knowledge of radiation-induced cataracts and ways to mitigate occupational risk.

Program Structure

Developing a radiation protection educational module will require a thorough organizational assessment to identify gaps in knowledge and the significance of the project to interested parties. The strengths, weaknesses, opportunities, and threats (SWOT) will be evaluated to achieve the project's goal. Ideal participants are anesthesia providers, who will be asked to complete a survey before and after the module to gauge comprehension.

The study aims to determine anesthetists' knowledge of radiation protection and its implications for practice. The participants will be provided a questionnaire to measure their understanding of ionized radiation, protection, and cataract risk. Participants will then receive an educational module addressing occupational radiation exposure and ways to practice safely. This course will be provided to anesthesia providers through a PowerPoint presentation. After the module, participants will be asked to take a survey to analyze the results pre- and post-education.

Strengths

Studies have indicated radiology staff possesses insufficient knowledge about radiation protection[9]. Anesthesia and surgical personnel would benefit from detailed radiation protection education, including an understanding of the risks, radiation protection, and the inverse square principle; the farther the distance from the source of radiation, the less exposure risk.[6,2] Research has shown chronic low levels of radiation exposure increase the risk of eye opacities/cataracts with no clear threshold level, a result that challenges the ICRP's threshold dose for the ocular lens[15]. If the scattered radiation exposure to the anesthesia provider is 3x that for the radiologist, anesthetists who regularly work in high-volume environments with frequent fluoroscopic procedures need to wear leaded eye protection. Lead lenses drastically reduce lens radiation exposure, decreasing ionizing radiation by 70-89%[15]. Personal protective equipment such as good-fitting lead glasses and lead/acrylic ceiling screens should be used routinely to decrease eye exposure[20]. Various methods of shielding provide additive security, and the use of multiple modalities (shields, aprons, eyewear, drapes) will minimize exposure[9]

Weaknesses

The plan's weaknesses are internal barriers that may hinder the progress of the module. A survey of anesthesia providers revealed that when protecting themselves from radiation exposure, 78.5% of the participants reported using a thyroid shield, but only 31.3% of them wore lead goggles [9]. Studies continue to report a high percentage of anesthetists and surgical specialists with insufficient understanding of radiation hazards. These results highlight the need for education and attention to radiation hazards among these professions[9]. Low compliance rates with lead eyewear can be attributed to the inadequate supply of lead goggles in radiology settings when compared to other equipment like aprons and thyroid shields. Radiology employees should be educated on the adverse consequences of radiation exposure. Staff need to be encouraged to consistently wear lead goggles and practice radiation protection while increasing the accessibility of goggles in the radiology suite[9]

Opportunities

Anesthesia and surgical personnel would benefit from detailed radiation protection education, including an understanding of the risks, radiation protection, and the inverse square principle; the farther the distance from the source of radiation, the less exposure risk.[6,2] To reduce occupational eye lens dose absorption, three factors should be practiced; time, distance, and shielding[19]. Research has shown chronic low levels of radiation exposure increase the risk of eye opacities/cataracts with no clear threshold level. This result challenges the ICRP's threshold dose for the ocular lens[15]. If the scattered radiation exposure to the anesthesia provider is 3x that for the radiologist, anesthetists who regularly work in high-volume environments with frequent fluoroscopic procedures need to wear leaded eye protection. Lead lenses drastically reduce lens radiation exposure, decreasing ionizing radiation by 70-89%[15]. Personal protective equipment such as good-fitting lead glasses and lead/acrylic ceiling screens should be used routinely to decrease eye exposure[20]. Various methods of shielding provide additive security, and the use of multiple modalities (shields, aprons, eyewear, drapes) will minimize exposure[9]

Threats

Factors that may hinder the growth of the educational intervention must be anticipated and evaluated. Risks to the module's success include anesthesia providers' reluctance to new evidence, bulky eyewear, and lack of awareness. Because the successful implementation of elevated radiology protection standards requires provider compliance, all workers in the radiology suite must feel a vested interest in the cause and understand their occupational risk. Leaded eyewear must be made available to all employees working under fluoroscopy, not just limited to interventionalists and technicians.

Methodology

Setting

The setting for this DNP project was Mount Sinai Medical Center (MSMC), a 672-bed hospital in Miami Beach, Florida.[21] MSMC is "Florida's largest private, independent, not-for-profit, teaching hospital." [21] Both certified registered nurse anesthetists (CRNAs) and anesthesiologists provide anesthesia services in 26 operating suites, including the main operating room (OR), ambulatory surgery, cardiac cath lab, interventional radiology, obstetrics, and more.[21]

Recruitment and Participants

The project was approved by the Institutional Review Boards (IRB), and email addresses were obtained from the MSMC anesthesia providers. The emails and results remained confidential to preserve privacy. An email was sent to anesthesia staff containing the pre-test, educational module, and post-test. Participation was voluntary and remained anonymous.

Intervention and Procedures

The educational intervention aimed to increase anesthesia providers' knowledge about the risks of ionizing radiation and cataract development as well as adequate eye protection. Enhancing knowledge and disseminating information takes time and one must adhere to protocols. The proposed plan was submitted and approved by Florida International University and IRB, as well as submitted to Miami Beach Anesthesiology Associates, in which an IRB waiver was obtained. An invitation to the educational module was distributed to CRNAs and anesthesiologists at MSMC via email. The link included a description of the project, consent for voluntary participation, a pre-test, an educational PowerPoint, and a post-test. A pre-test was used to assess current knowledge of radiation hazards and protective equipment and to determine the level of knowledge deficit. The evidence-based educational PowerPoint included a background of the problem, current knowledge of ionizing radiation, current standards, a discussion of results, and implications for clinical practice. This voiceover PowerPoint allowed participants to either listen to the speaker for auditory learners or read through the PowerPoint for visual learners. A post-test assessed if learning had occurred and how likely participants would be to wear adequate PPE, including leaded glasses. The author's contact information was provided to participants if they had any questions or concerns.

Protection of Human Subjects

No employee identifiers were used when collecting or storing data, and no medical records were accessed to extrapolate data. All survey responses remained anonymous throughout the project to protect individual rights and privacy. Potential benefits to participants include improved knowledge of radiation safety and steps to mitigate risk. It is expected that this study will benefit healthcare providers with occupational radiation exposure. Participants are not expected to experience any risks, harm, or discomfort during the project.

Data Collection

The educational intervention will be taught using a PowerPoint presentation to meet objectives. A pre/post-assessment questionnaire will determine the efficacy of the outcomes. The target population will comprise approximately 10 healthcare providers working at Mount Sinai Medical Center. With their consent, participants will complete an anonymous pre-test survey to assess their knowledge, perceptions, and current clinical practices. Participants will then watch an educational PowerPoint based on the findings of an evidence-based systematic review and fill out a post-test. Both assessments will be conducted using surveys of approximately 10 questions focusing on knowledge and practice using Qualtrics. Reliability and validity will be measured following IRB standards. All data collected will remain confidential without subject identifiers throughout the study.

Data Management/ Analysis

Participants will be given two weeks to complete the survey and educational module link contained in the email. All responses will be exported from Qualtrics into Excel software to compare the statistical difference between pre-test and post-test answers. This comparative analysis will help determine anesthetists' current knowledge and practices as well as perceptions of the educational intervention and what kind of learning occurred.

Results

Demographics

A total of 66 invitations were distributed via email to anesthesia providers to participate in the pre-and post-test educational intervention. Six participants completed the study in its entirety. The demographics of those who participated are represented as follows: average age 39.5 years old, ethnicity Hispanic (n=6, 100%), with no participants of Caucasian, African American, Asian, or other descent. All participants were certified registered nurse anesthetists (n = 6, 100%), with a graduate degree. Participants were also asked about their years of practice in the profession as a certified registered nurse anesthetist (CRNA) and a variety of results were found: 1-2 years (n=3, 50%), 2-5 years (n=1, 16.67%), 5-10 years (n= 0, 0.0%), and over 10 years (n=2, 33.33%).

The demographics of participants surveyed are represented below.

Consent to Participate

Answer	%	Total
Consent to participate	100%	6
Decline to participate	0.0%	0
Total	100%	6

Ethnicity

Answer	%	Total
Hispanic	**100%**	**6**
Caucasian (non-Hispanic)	**0%**	**0**
African American	**0%**	**0**
Asian	**0%**	**0**
other	**0%**	**0**
Total	**100%**	**6**

Position/Title

Answer	%	Total
Certified Registered Nurse Anesthetist (CRNA)	**100%**	**6**
Other	**0%**	**0**
Total	**100%**	**6**

Level of Education

Answer	%	Total
Associates Degree	**0%**	**0**
Bachelor's Degree	**0%**	**0**
Graduate Degree	**100%**	**6**
Other	**0%**	**0**
Total	**100%**	**6**

How many years have you been an anesthesia provider?

Answer	%	Total
1-2 years	**50.0%**	**3**
2-5 years	**16.67%**	**1**
5-10 years	**0.0%**	**0**
Over 10 years	**33.33%**	**2**
Total	**100%**	**6**

Pre- Test Knowledge of Radiation and Occupational Exposure Risks

The pre-test consisted of 11 questions assessed the current knowledge of ionizing radiation, radiation protection, and occupational radiation exposure. Only two participants (33.3%) correctly identified the most radiosensitive tissue in the body as the eye/ocular lens. In contrast, half of the participants (n=3, 50%), believed the thyroid to be the most sensitive, followed by 1 participant who chose sex organs (16.67%). Five participants (83.3%) felt that all types of anesthesia (General anesthesia with endotracheal tube, LMA, or monitored anesthesia care/ MAC) confer equal occupational radiation risk, with only one (16. 67%) correctly selecting MAC as the highest risk to the anesthesia provider. Almost all participants (n=5, 83.3%) identified adequate eye protection as leaded eyeglasses and ceiling screens, with only one (16.67%) selecting a clear plastic face shield. Only two participants (33.3%) selected the appropriate response to the cause of radiation-induced cataracts, with any radiation exposure causing harm without threshold limits necessary to cause damage. Five participants (83.3%) correctly recognized that occupational radiation dose reduction depends on the length of exposure, distance to the source, and protective shielding. All participants (n=6, 100%) understood that the use of leaded eye protection provides 98% radiation reduction.

Pre- Test Attitudes/ Beliefs/ Perceptions of Radiation Protection

Attitudes and everyday practices of radiation protection varied amongst those surveyed. 83% (n=5) of participants reported wearing a leaded apron and thyroid shield during routine fluoroscopic procedures, with only one (16.6%) reporting using a leaded apron, thyroid shield, and leaded glasses. All participants (n=6, 100%) reported never wearing protective eyewear as an additional measure of protection during radiography. Every participant (100%) also stated their healthcare facility did not provide leaded eye protection for employees. Every participant reported being most likely (n=3, 60%), or somewhat likely (n=2, 40%) to use additional personal protective equipment, including leaded glasses, to limit occupational radiation exposure during radiology/fluoroscopy.

Post- Test Knowledge of Radiation and Occupational Exposure Risks

Six participants completed the post-test evaluating their knowledge of radiation and exposure after completing the educational intervention. Half of the participants (n=3, 50%) still did not know that the ocular lens is the most radiosensitive tissue in the body. Four participants (66.6%) correctly understood that MAC anesthesia poses the highest risk of radiation to the anesthetist.

Following the educational module, all participants (n=6, 100%) reported that leaded glasses and ceiling screens comprised effective eye protection. Half of the participants (n=3, 50%) did not understand that any radiation exposure, regardless of dose can cause damage. Almost all participants (n=5, 83.3%) understood the appropriate radiation dose reduction measures of time, distance, and shielding. Following the intervention, all participants (n=6, 100%) understood that the use of leaded eye protection provides 98% radiation reduction.

Post- Test Attitudes/ Beliefs/ Perceptions of Radiation Protection

Attitudes and perceptions towards radiation protection increased significantly following the educational module. All participants (n=6, 100%) said they would likely use additional protective equipment and wear leaded glasses to limit occupational radiation exposure. Conversely, all participants (n=6, 100%) reported never wearing leaded glasses during fluoroscopy due to their facility not providing them (n=5, 83.3%), or their peers who do use eye protection bring their own (n=1, 16.67%).

Summary of Data

Overall, the results of the educational intervention demonstrated an increase in knowledge and perceptions between the pre-test and post-tests. The most significant areas of growth were observed by correctly identifying the type of anesthesia that poses the greatest risk of radiation exposure to the anesthetist (MAC anesthesia), and adequate eye protection items (leaded glasses and lead/acrylic ceiling screens). Participants, however, remained confused about the most radiosensitive tissue in the body, with only half (n=3, 50%) correctly identifying the eye/ocular lens in the post-test after education had taken place.

The graphs below illustrate the difference between the pre-and post-test responses of attitudes and perceptions of using personal protective items to limit occupational radiation exposure.

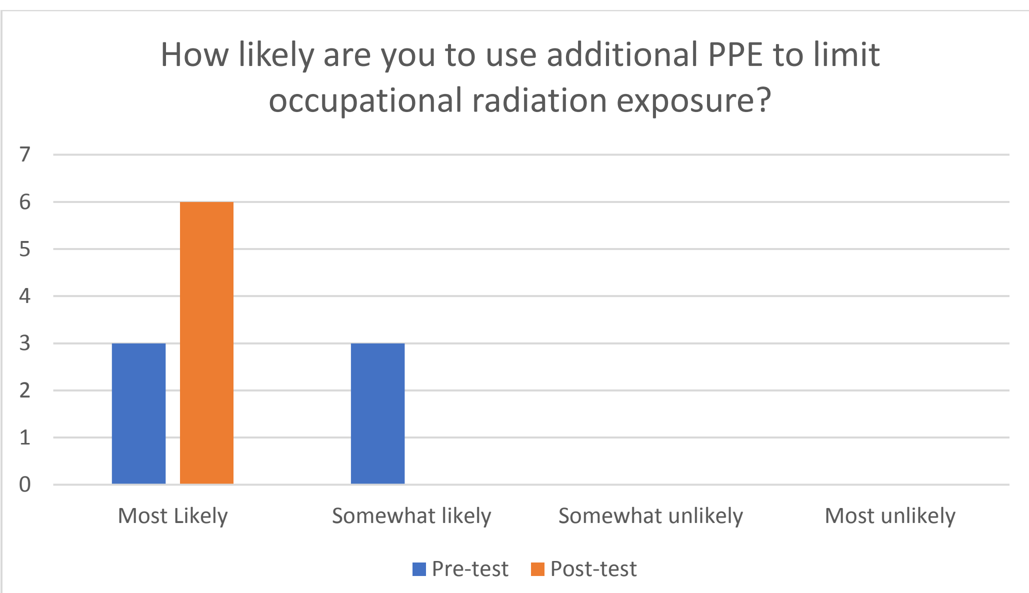

Figure 1. How likely are you to use additional personal protective equipment (PPE) to limit occupational radiation exposure?

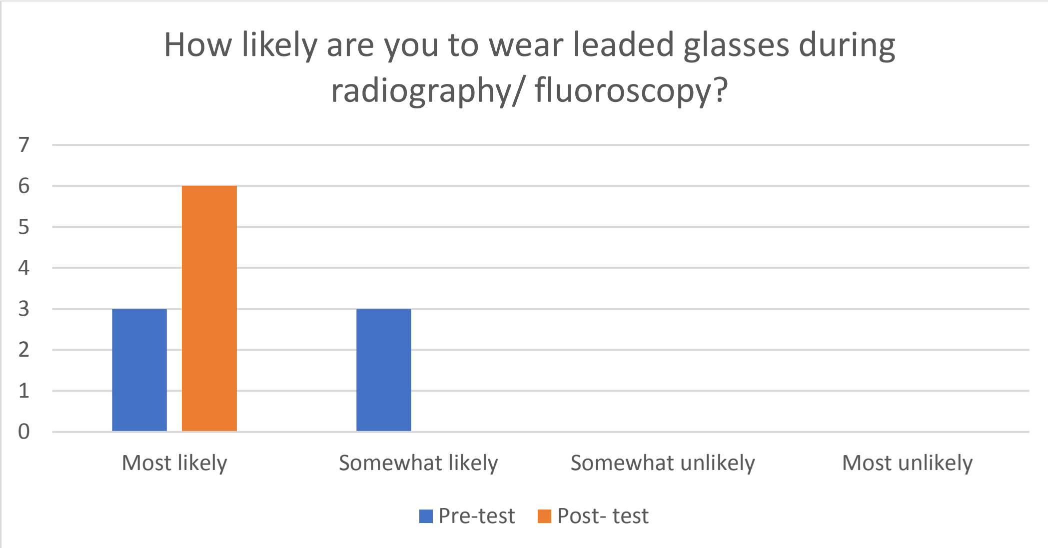

Figure 2. How likely are you to wear leaded glasses during radiography/fluoroscopy?

Discussion

Limitations

This quality improvement project had several limitations, including a small sample size. Sixty-six surveys were distributed via email to anesthesia providers in the Alumni group at Florida International University, however, only 6 participants completed the pre-test, educational intervention, and post-test. A larger, more diverse sample size would have increased the strength and reliability of the study. Additionally, a larger sample size would validate the efficacy of the educational intervention. Another limitation is the time frame. Participants were allowed two weeks to complete the survey. Additional time may have allowed for an increased response rate. Lastly, it is recognized that this quality improvement project only took place within the Alumni group. If distributed within multiple locations, results would more accurately reflect anesthesia providers instead of just one community.

Future Implications for Advanced Nursing Practice

Anesthesia services are becoming more commonplace within radiology locations, often without the conventional tools and protections in the standard operating suite. During radiography or fluoroscopy, anesthesia providers are inadvertently exposed to radiation. Studies have long demonstrated the risks associated with radiation exposure, including infertility and birth defects, bone marrow suppression, cancer, and cataract formation. Anesthetists are regularly exposed to radiation while caring for patients, and there is a heightened concern for personal, and occupational radiation exposure. While lead garments adequately shield the trunk, the eye lens is at risk of unprotected exposure. Although anesthesia providers wear lead aprons and thyroid shields to protect their bodies from the neck down, the standard of practice for interventionalists and surgeons includes a ceiling-mounted lead shield to protect the face and the use of lead glasses. There are currently no similar standards regarding eye protection for anesthesia providers during radiology, and anesthetists may be unaware they are leaving themselves exposed. Evidence has shown radiation exposure during fluoroscopy may well exceed the IRCP's threshold for eye injury. The exposure to the anesthesia provider can be as high as the dose reaching the radiologist, especially during interventional procedures. The outcomes of this study are important to enhance knowledge and personal safety practices amongst anesthesia providers and decrease occupational exposure risks.

Conclusions and Plan for Sustaining Change

Anesthesia providers must remain aware of occupational exposure risk and take the appropriate measures to minimize this. The three general principles of radiation protection as proposed by the ICRP include: limiting dose exposure, maximizing distance from the source, and using/wearing protective shielding. Education and training about radiation hazards and appropriate PPE are critical for anesthetists working in these environments. Studies have indicated radiology staff possesses insufficient knowledge about radiation protection. Anesthesia and surgical personnel would benefit from detailed radiation protection education, including an understanding of the risks, radiation protection, and the inverse square principle. To reduce occupational eye lens dose absorption, three factors should be practiced: time, distance, and shielding. Personal protective equipment including good-fitting lead glasses, and lead/acrylic ceiling screens, should be used routinely to decrease eye exposure. Various methods of shielding provide additive security, and using multiple modalities (shields, aprons, eyewear, drapes) will minimize risk. The goal of this project is to improve the knowledge, attitudes, and perception of anesthesia providers and radiation safety. The knowledge gained could ultimately reduce occupational exposure to radiation while decreasing the incidence of radiation-induced cataracts. This educational module could be presented to hospitals and healthcare administration to gain support to implement enhanced radiation safety standards.

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Appendix A: IRB Exemption

FLORIDA INTERNATIONAL UNIVERSITY

Office of Research Integrity
Research Compliance, MARC 414

MEMORANDUM

To:	Dr. Jorge Valdes
CC:	Elizabeth Filbert
From:	Elizabeth Juhasz, Ph.D., IRB Coordinator
Date:	March 28, 2022
Protocol Title:	**"Occupational radiation exposure and cataract development: A quality improvement project"**

The Florida International University Office of Research Integrity has reviewed your research study for the use of human subjects and deemed it Exempt via the **Exempt Review** process.

IRB Protocol Exemption #:	IRB-22-0112	**IRB Exemption Date:**	03/28/22
TOPAZ Reference #:	111551		

As a requirement of IRB Exemption you are required to:

1) Submit an IRB Exempt Amendment Form for all proposed additions or changes in the procedures involving human subjects. All additions and changes must be reviewed and approved prior to implementation.
2) Promptly submit an IRB Exempt Event Report Form for every serious or unusual or unanticipated adverse event, problems with the rights or welfare of the human subjects, and/or deviations from the approved protocol.
3) Submit an IRB Exempt Project Completion Report Form when the study is finished or discontinued.

Special Conditions: N/A

For further information, you may visit the IRB website at http://research.fiu.edu/irb.

Appendix B: QI Project Consent

FLORIDA INTERNATIONAL UNIVERSITY

CONSENT TO PARTICIPATE IN A QUALITY IMPROVEMENT PROJECT

"An Educational Module for Occupational radiation exposure and risk of cataract development"

SUMMARY INFORMATION

Things you should know about this study:

- **Purpose:** Educational module concerning upgraded PPE and use of leaded eyewear to decrease the incidence of cataracts amongst anesthesia providers
- **Procedures**: Participate in a pre-test view and an Educational Module via voice-over PowerPoint then participate in a post-test
- **Duration:** This will take about a total of 20 minutes total.
- **Risks**: The main risk or discomfort from this research is minimal
- **Benefits:** The main benefit to you from this research is to increase the participant's knowledge of personal protective equipment and occupational radiation hazards.
- **Alternatives:** There are no known alternatives available to you other than not taking part in this study.
- **Participation:** Taking part in this research project is voluntary. Please carefully read the entire document before agreeing to participate.

PURPOSE OF THE PROJECT

The goal of this project is to enhance knowledge of occupational radiation risks and the use of leaded eyewear for cataract prevention through an educational intervention targeting certified registered nurse anesthetists (CRNAs). You are being asked to participate in this quality improvement project

DURATION OF THE PROJECT

Your participation will require about 20 minutes of your time, you will be one of 10 people in this study

PROCEDURES

If you agree to be in the project, we will ask you to do the following things: Participate in a pre-test view an Educational Module via voice-over PowerPoint then participate in a post-test

RISKS AND/OR DISCOMFORTS

Minimal risk, risk not greater than if the participant was conducting a similar activity. Physical, psychological, social, legal, and economic risks are minimal and no greater than if a participant was participating in a similar activity. Similar activities include filling out an online survey and watching voice-over PowerPoint.

BENEFITS
The following benefits with your participation in this project: An increase in your knowledge surrounding radiation exposure, proper PPE, cataract development, and use of protective leaded eyewear.

ALTERNATIVES
There are no known alternatives available to you other than not taking part in this project. However, if you would like to receive the educational material given to the participants in this project, it will be provided to you at no cost.

CONFIDENTIALITY
The records of this project will be kept private and will be protected to the fullest extent provided by law. If, in any sort of report, we might publish, we will not include any information that will make it possible to identify you as a participant. Records will be stored securely, and only the project team will have access to the records.

PARTICIPATION: Taking part in this research project is voluntary.

COMPENSATION & COSTS
There is no cost or payment to you for receiving the health education and/or for participating in this project.

RIGHT TO DECLINE OR WITHDRAW
Your participation in this project is voluntary. You are free to participate in the project or withdraw your consent at any time during the project. Your withdrawal or lack of participation will not affect any benefits to which you are otherwise entitled. The investigator reserves the right to remove you without your consent at such time that they feel it is in their best interest.

RESEARCHER CONTACT INFORMATION
If you have any questions about the purpose, procedures, or any other issues relating to this research project, you may contact Elizabeth Filbert at 712-355-3535, efilb001@fiu.edu , or Dr. Jorge Valdes at 305-348-7729/jvalde@fiu.edu.

IRB CONTACT INFORMATION
If you would like to talk with someone about your rights pertaining to being a subject in this project or about ethical issues with this project, you may contact the FIU Office of Research Integrity by phone at 305-348-2494 or by email at ori@fiu.edu.

PARTICIPANT AGREEMENT
I have read the information in this consent form and agree to participate in this study. I have had a chance to ask any questions I have about this study, and they have been answered for me. By clicking on the “consent to participate” button below I am providing my informed consent.

Appendix C: Recruitment Letter

Nicole Wertheim College of Nursing and Health Sciences Department of Nurse Anesthesiology

Occupational radiation exposure and cataract development: An Evidence-Based Educational Module

My name is Elizabeth Filbert, and I am a student in the Anesthesiology Nursing Program Department of Nurse Anesthetist Practice at Florida International University. I am writing to invite you to participate in my quality improvement project. The goal of this project is to improve the knowledge, attitudes, and perception of anesthesia providers and radiation safety. The knowledge gained could ultimately reduce occupational exposure to radiation while decreasing the incidence of radiation-induced cataracts. You are eligible to take part in this project because you are an Anesthesia alumnus at Florida International University.

If you decide to participate in this project, you will be asked to complete and sign a consent form for participation. Next, you will complete a pre-test questionnaire, which is expected to take approximately 5 minutes. You will then be asked to view an approximately 15-minute-long educational presentation online. After watching the video, you will be asked to complete the post-test questionnaire, which is expected to take approximately 5 minutes. No compensation will be provided.

Remember, this is completely voluntary. You can choose to be in the study or not. If you'd like to participate or have any questions about the study, please email or contact me at efilb001@fiu.edu or 712-355-3535

Thank you very much. Sincerely,
Elizabeth Filbert

Appendix D: Letter of Support

Department of Nurse Anesthesiology

Nicole Wertheim College of Nursing & Health Sciences

February 2, 2022

Jorge Valdes DNP, CRNA, APRN Clinical Associate Professor
Department of Nurse Anesthesiology Florida International University

Dear Dr. Valdes,

I thank you for inquiring about the use of the FIU DNAP alumni list for participation in the Doctor of Nursing Practice (DNP) project conducted by Elizabeth Filbert entitled "Educational Module on Occupational radiation exposure and cataract development" in the Nicole Wertheim College of Nursing and Health Sciences, Department of Nurse Anesthetist Practice at Florida International University. I have granted Ms. Filbert permission to conduct the project using our providers.

Evidence-based practice's primary aim is to yield the best outcomes for patients by selecting evidence-supported interventions. This project intends to evaluate if a structured education targeting anesthesia providers will increase knowledge on Occupational radiation exposure and cataract development in the operating room.

We understand that participation in the study is voluntary and carries no overt risk. All Alumni Anesthesiology providers are free to participate or withdraw from the study at any time. The educational intervention will be conveyed by a 15-minute virtual PowerPoint presentation, with a pretest and posttest questionnaire delivered by a URL link electronically via Qualtrics, an online survey product. Responses to pretest and posttest surveys are not linked to any participant. The collected information is reported as an aggregate, and there is no monetary compensation for participation. All collected material will be kept confidential, stored in a password-encrypted digital cloud, and only be accessible to the investigators of this study: Elizabeth Filbert and Dr. Valdes.

Once the Institutional Review Board's approval is achieved, this scholarly project's execution will occur over two weeks. Elizabeth Filbert will behave professionally, and follow standards of care. We support the participation of our Anesthesiology providers in this project and look forward to working with you.

Sincerely,

Ann Miller, DNP, CRNA, APRN
Interim Assistant Chair, Department of Nurse Anesthesiology Associate Professor

Appendix E: Pretest and Posttest Questionnaire

FLORIDA INTERNATIONAL UNIVERSITY

INTRODUCTION

The primary aim of this QI project is to expand the knowledge of occupational radiation exposure to enhance the standards of personal protective equipment (PPE) and decrease the incidence of cataract development amongst anesthesia providers.

Please answer the question below to the best of your ability. The questions are either in multiple choice or true/false format and are meant to measure knowledge and perceptions on PPE and occupational radiation exposure.

PERSONAL INFORMATION

1. **Gender:** Male ____ Female______ Non-Binary________
2. **Age:** ______
3. **Ethnicity:**

   Hispanic Caucasian African American Asian Other ___________

4. **Position/Title:** _________________________________
5. **Level of Education:** Associates Bachelors Masters Other_______________
6. How many years have you been an anesthesia provider?

   Over 10 5-10 years 2-5 years 1-2 years

QUESTIONNAIRE

1. **During a fluoroscopic procedure, the personal protective equipment (PPE) you typically don is:**
   0. **Leaded apron**
   1. **Leaded apron, thyroid shield**
   2. **Leaded apron, thyroid shield, leaded glasses/ lead shield**
   3. **Stand behind a lead/acrylic curtain**

2. **What is your perception of using eyewear as an additional measure to protect against absorbed scatter radiation during fluoroscopy/radiography?**
    0. **I never wear eyewear**
    1. **I sometimes wear eyewear when I have it/when it is available**
    2. **I most always wear eyewear**

3. **How available is leaded eyewear in your current healthcare facility?**
    0. **My facility does not provide leaded eye protection for employees**
    1. **My peers who use eye protection bring their own**
    2. **My facility provides leaded eye protection for employees**

4. **The most radiosensitive tissue in the human body is:**
    0. **Thyroid**
    1. **Eyes/ ocular lens**
    2. **Skin**
    3. **Sex organs**

5. **Which type of anesthesia increases the risk of higher radiation exposure to the anesthesia provider?**
    0. **Monitored Anesthesia Care (MAC)**
    1. **General anesthesia with endotracheal intubation**
    2. **General anesthesia with a supraglottic airway (LMA)**
    3. **All the above**

6. **Which items below comprise adequate eye protection from radiation?**
    0. **Clear plastic face shield**
    1. **Leaded eyeglasses and lead/acrylic ceiling screens**
    2. **Thyroid shield and plastic goggles**
    3. **Laser safe goggles**

7. **Radiation induced cataracts are caused by:**
    0. **Repeated exposure to radiation, with the dose absorbed having to reach a threshold limit before causing harm**
    1. **Any exposure to radiation can cause harm, with no threshold limit needed to cause damage**
    2. **Genetic predisposition**
    3. **None of the above**

8. **Occupational radiation dose REDUCTION is dependent upon these factors:**
    0. **Time, distance, shielding**
    1. **Type of anesthesia, use of magnet, total intravenous anesthesia (TIVA)**
    2. **Use of neuraxial (epidurals or spinals)**

9. **The use of leaded glasses provides 98% or greater radiation reduction?** True or False

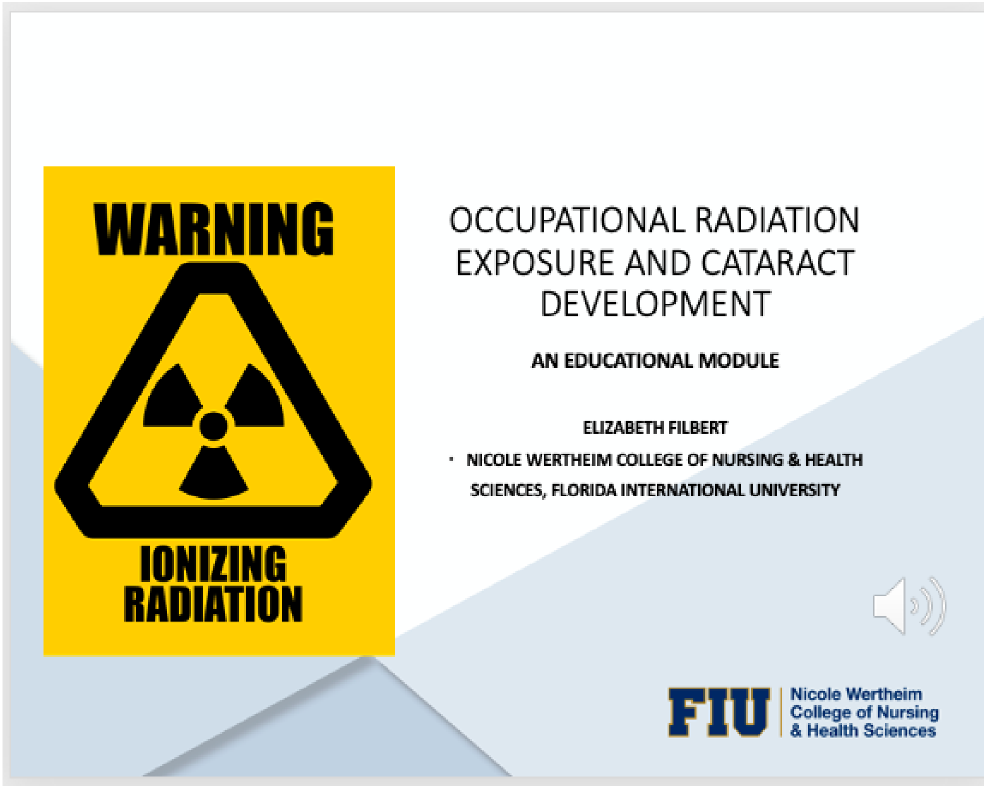
10. How likely are you to use additional personal protective equipment (PPE) to limit occupational radiation exposure?

1. Most likely
2. Somewhat likely
3. Somewhat unlikely
4. Most unlikely

11. How likely are you to wear leaded glasses during radiography/fluoroscopy?

1. Most likely
2. Somewhat likely
3. Somewhat unlikely
4. Most unlikely

Appendix F: QI Educational Module


WARNING
IONIZING
RADIATION
OCCUPATIONAL RADIATION EXPOSURE AND CATARACT DEVELOPMENT
AN EDUCATIONAL MODULE
ELIZABETH FILBERT
· NICOLE WERTHEIM COLLEGE OF NURSING & HEALTH SCIENCES, FLORIDA INTERNATIONAL UNIVERSITY
FIU
Nicole Wertheim
College of Nursing
& Health Sciences


OBJECTIVES
The goal of this project is to improve the knowledge, attitudes, and perception of anesthesia providers and radiation safety. The knowledge gained could ultimately reduce occupational exposure to radiation while decreasing the incidence of radiation-induced cataracts.
FIU
Nicole Wertheim
College of Nursing
& Health Sciences

PROBLEM IDENTIFICATION

exposure to low levels of medical radiation can increase the risk of several types of cancer, cause bone marrow suppression, infertility, birth deformities, and cataracts.

- Anesthetists are inadvertently exposed to radiation due to the frequent use of radiography, fluoroscopy, and computed tomography in the intraoperative area

- Studies have demonstrated average radiation exposure to anesthesia providers doubles (2x) after staffing an electrophysiology laboratory.
- Additional studies have demonstrated the radiation dose to the anesthesia provider's eye can be greater than 3x the interventionalist.

- In neurointerventional procedures, radiation exposure to the anesthesiologist's face was 6x greater than that of the radiologist performing the surgery.
- This demonstrates the significant implications of radiation protection to all anesthesia providers

FIU Nicole Wertheim College of Nursing & Health Sciences

BACKGROUND

High radiation exposures occur during many conscious sedation/ monitored anesthesia care procedures.

The radiation dose of the provider directly correlates with the amount of care the patient requires. Each intervention from the anesthetist (boluses, infusion changes), increases his or her radiation exposure by 0.42 Sv.

When the anesthesia provider is working in the close vicinity of the patient during periods of apnea or hemodynamic instability, the protection from the ceiling shield fails.

During neurovascular procedures, the anesthesia provider is working close to the field, which accounts for radiation doses 4x times higher during EVAR procedures

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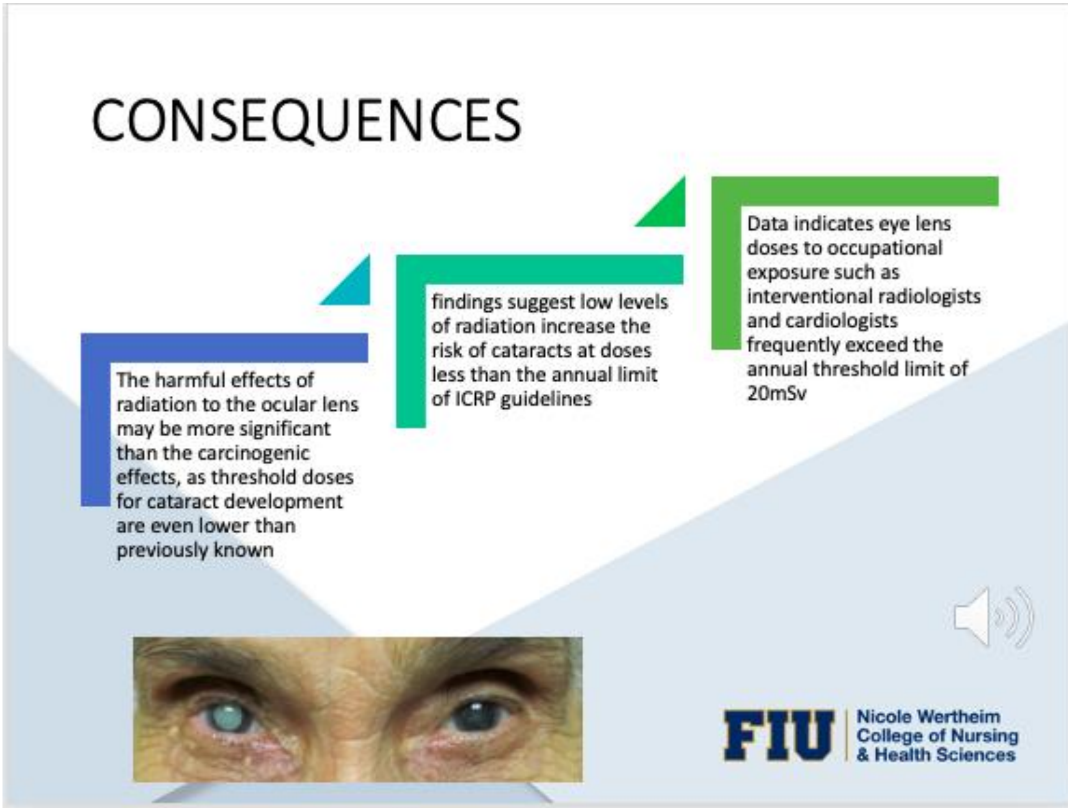
CONSEQUENCES
The harmful effects of radiation to the ocular lens may be more significant than the carcinogenic effects, as threshold doses for cataract development are even lower than previously known
findings suggest low levels of radiation increase the risk of cataracts at doses less than the annual limit of ICRP guidelines
Data indicates eye lens doses to occupational exposure such as interventional radiologists and cardiologists frequently exceed the annual threshold limit of 20mSv
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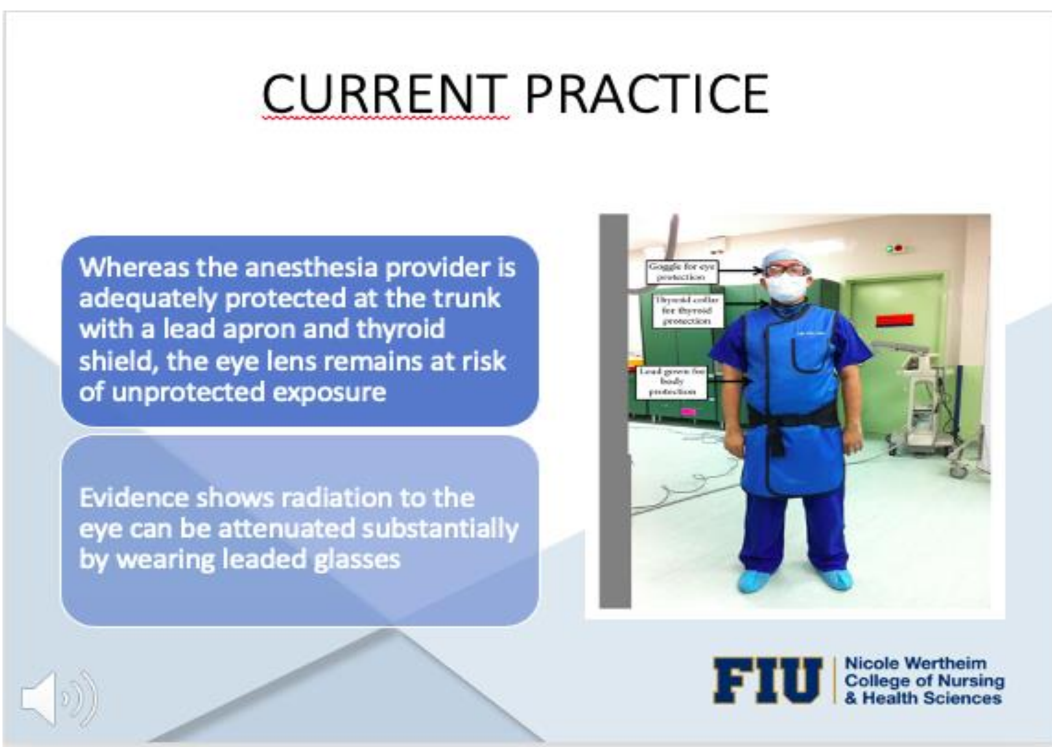
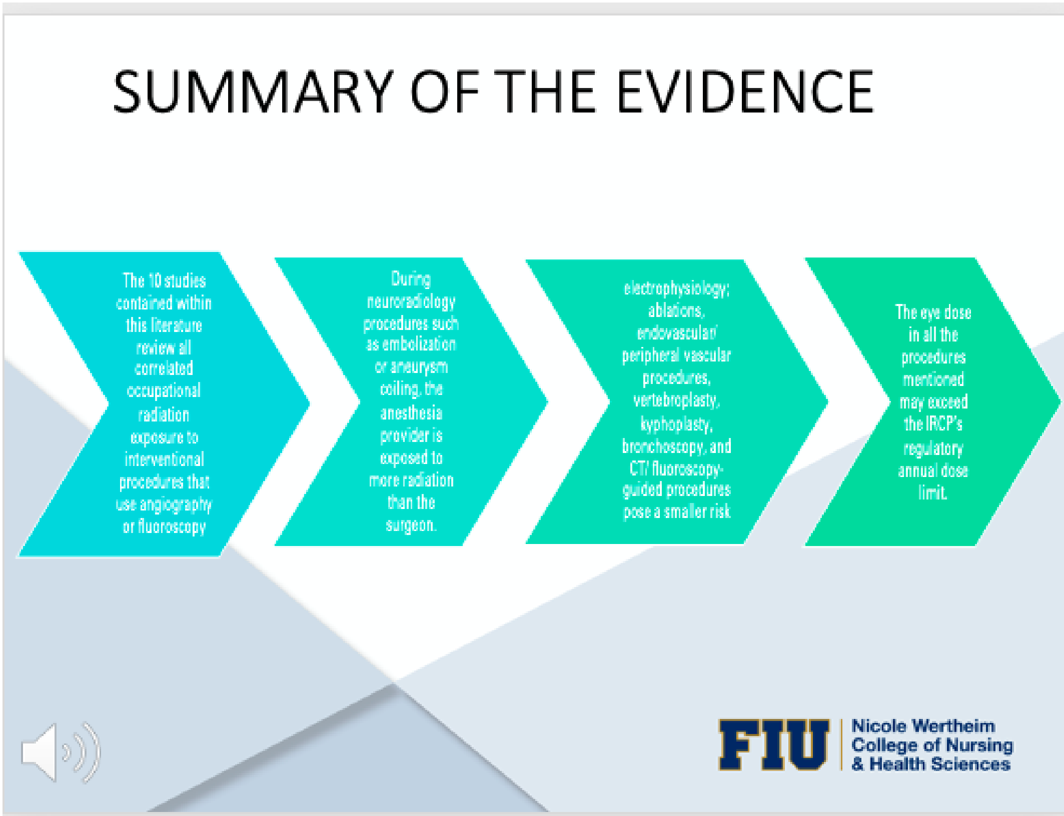
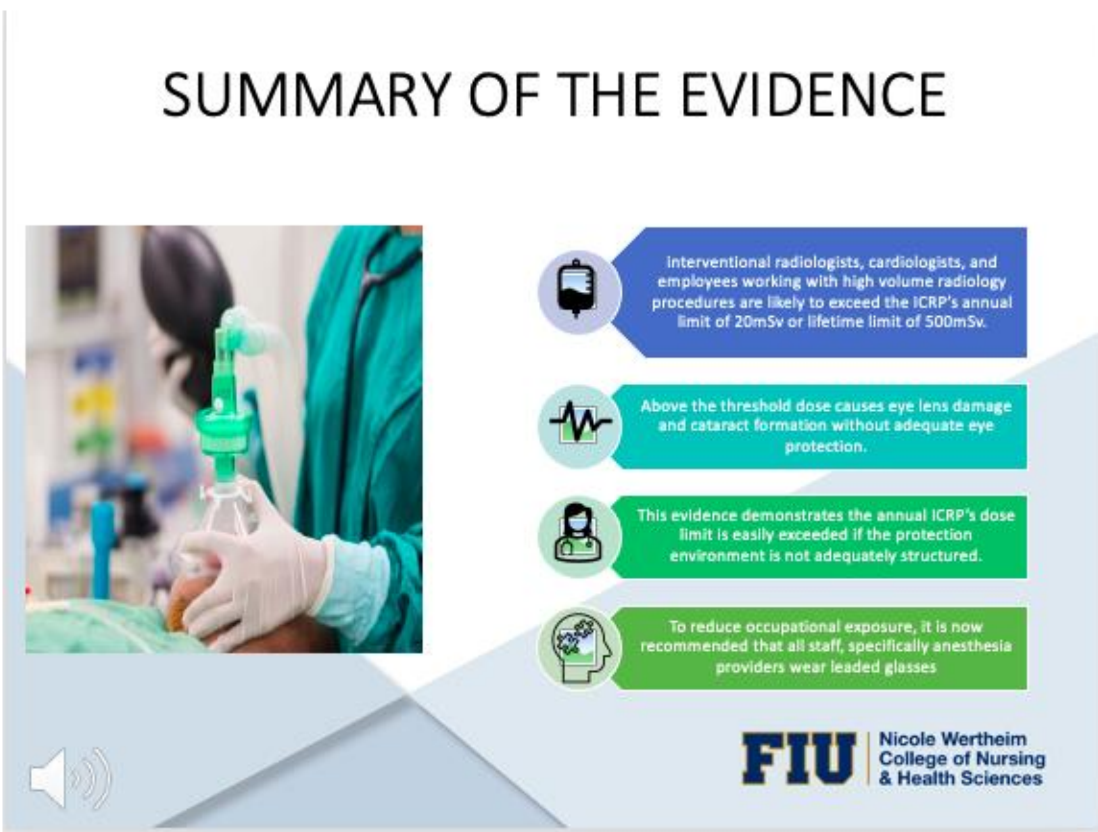
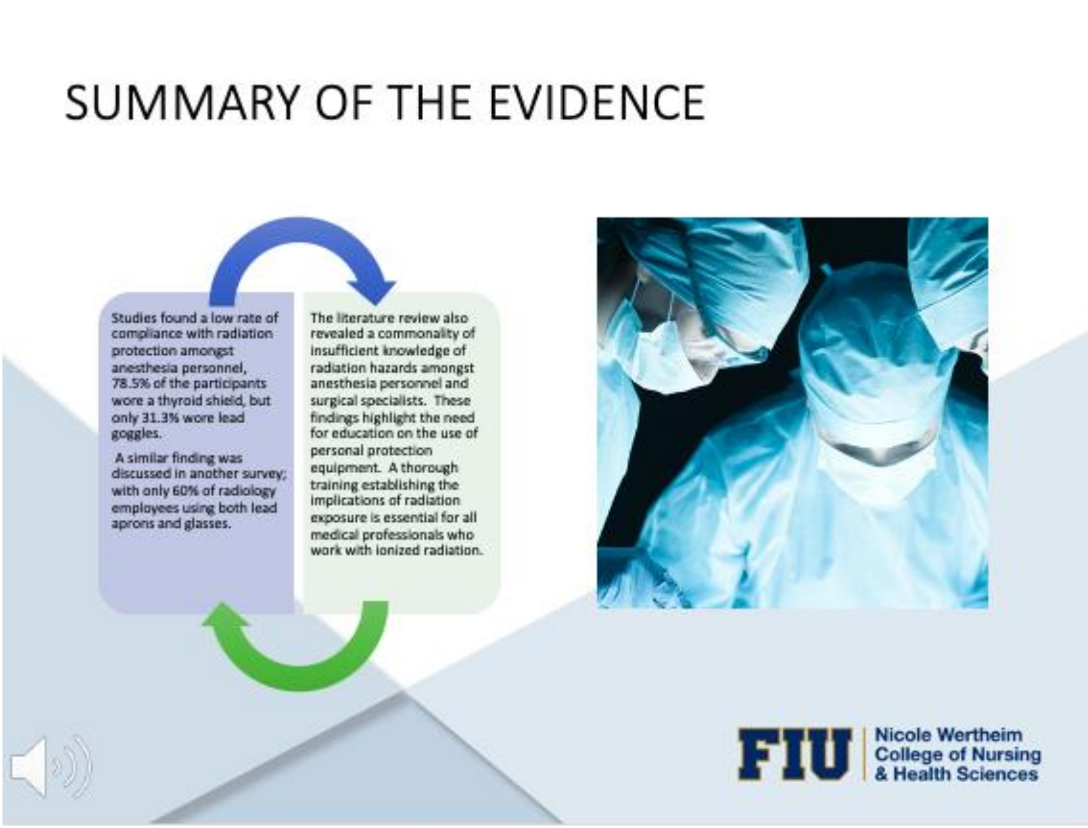

CURRENT PRACTICE
Whereas the anesthesia provider is adequately protected at the trunk with a lead apron and thyroid shield, the eye lens remains at risk of unprotected exposure
Evidence shows radiation to the eye can be attenuated substantially by wearing leaded glasses
Goggle for eye protection
Thyroid collar for thyroid protection
Lead gown for body protection
FIU
Nicole Wertheim College of Nursing & Health Sciences


SUMMARY OF THE EVIDENCE
The 10 studies contained within this literature review all correlated occupational radiation exposure to interventional procedures that use angiography or fluoroscopy
During neuroradiology procedures such as embolization or aneurysm coiling, the anesthesia provider is exposed to more radiation than the surgeon.
electrophysiology; ablations, endovascular/ peripheral vascular procedures, vertebroplasty, kyphoplasty, bronchoscopy, and CT/ fluoroscopy-guided procedures pose a smaller risk
The eye dose in all the procedures mentioned may exceed the IRCP's regulatory annual dose limit.
FIU
Nicole Wertheim
College of Nursing
& Health Sciences


SUMMARY OF THE EVIDENCE
Interventional radiologists, cardiologists, and employees working with high volume radiology procedures are likely to exceed the ICRP's annual limit of 20mSv or lifetime limit of 500mSv.
Above the threshold dose causes eye lens damage and cataract formation without adequate eye protection.
This evidence demonstrates the annual ICRP's dose limit is easily exceeded if the protection environment is not adequately structured.
To reduce occupational exposure, it is now recommended that all staff, specifically anesthesia providers wear leaded glasses
FIU
Nicole Wertheim
College of Nursing
& Health Sciences


SUMMARY OF THE EVIDENCE
Studies found a low rate of compliance with radiation protection amongst anesthesia personnel, 78.5% of the participants wore a thyroid shield, but only 31.3% wore lead goggles.
A similar finding was discussed in another survey; with only 60% of radiology employees using both lead aprons and glasses.
The literature review also revealed a commonality of insufficient knowledge of radiation hazards amongst anesthesia personnel and surgical specialists. These findings highlight the need for education on the use of personal protection equipment. A thorough training establishing the implications of radiation exposure is essential for all medical professionals who work with ionized radiation.
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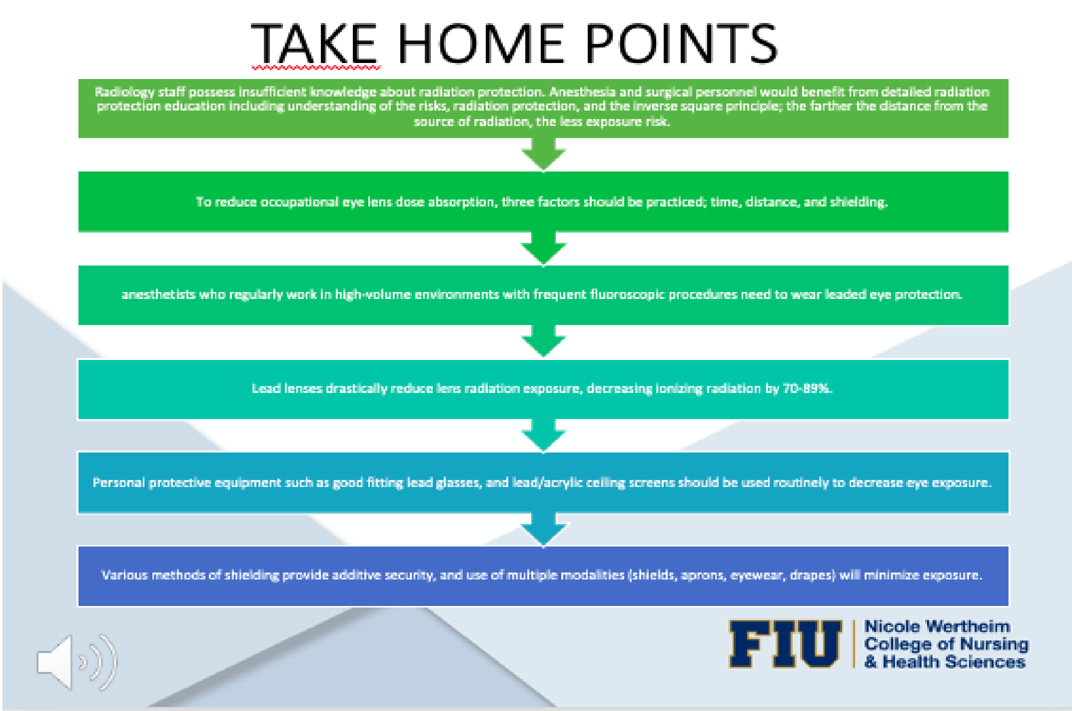
TAKE HOME POINTS
Radiology staff possess insufficient knowledge about radiation protection. Anesthesia and surgical personnel would benefit from detailed radiation protection education including understanding of the risks, radiation protection, and the inverse square principle; the farther the distance from the source of radiation, the less exposure risk.
To reduce occupational eye lens dose absorption, three factors should be practiced; time, distance, and shielding.
anesthetists who regularly work in high-volume environments with frequent fluoroscopic procedures need to wear leaded eye protection.
Lead lenses drastically reduce lens radiation exposure, decreasing ionizing radiation by 70-89%.
Personal protective equipment such as good fitting lead glasses, and lead/acrylic ceiling screens should be used routinely to decrease eye exposure.
Various methods of shielding provide additive security, and use of multiple modalities (shields, aprons, eyewear, drapes) will minimize exposure.
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Table 1. Overview of Literature Review Results

Author(s)	Purpose	Methodology/ Research Design	Intervention(s)/ Measures	Sampling/Setting	Primary Results	Relevant Conclusions
1. Vano (2015)		Level IV Recommendations Guidelines				Different medical specialists need dedicated training, supervision, and advice to practice safely. Radiation risks and thresholds for exposure proposed by the IRCP, especially for the lens of the eye and CV system are a cause of concern in some groups of healthcare professionals
2. Wang, Kumar, Tanaka, & Macario (2017)	This article highlights key learning points related to basic physical principles, effects of ionizing radiation, exposure, measurement, occupational dose limits, considerations sources of exposure, factors affecting occupational exposure such as	Level V quality improvement	implemented an opt-in radiation dosimeter program for the anesthesiology residents. did not meet the federal regulatory definition of research	Fifty-one residents initially agreed to participate and were given a ring dosimeter for 3 months to measure shallow dose exposure, which was then exchanged for a thermoluminescent dosimeter to measure deep, eye, and shallow dose exposure for the subsequent 3 months	The measurements indicated that the anesthesiology residents had low overall measured occupational radiation exposure	Our quality improvement project involving resident exposure and published studies suggest that occupational radiation doses are generally well below the recommended threshold. However, continued education and awareness of the risks, improvements in radiation shielding, and increasing distance from the source of ionizing radiation will reduce exposure and

	positioning, shielding, monitoring.					the potential for associated sequelae.
3. Kleiman (2012)	New recommendations have significant implications for human ocular health risks following occupational, accidental, or terrorist exposures, and highlight a pressing need to better estimate the risk of radiation-induced lens pathology.	Level IV Guidelines				Recent human epidemiological findings for acutely, protracted, and chronically exposed populations have led to significant downward revisions in ICRP thresholds for cataract risk. Better techniques for detecting, quantifying, and documenting early radiation-associated lens changes have all contributed to the findings of radiation cataract risk at very low exposures
4. Merrachi, Bouchard-Bellavance, Perreault, et al (2021)	To quantify eye lens dose in interventional radiology and assess whether neck dosimeter is a good surrogate to evaluate eye lens dosimetry	Level I Quantitative Study	Radiation exposure was prospectively measured in 9 interventional radiologists between May and October 2017. Standard dosimeters were worn at the neck outside the lead apron, and dedicated eye lens dosimeters were worn just above the eyes, one midline and another at the outer edge of the left eye.	Seven IRs and 4 fellows in interventional radiology from a university medical center were monitored over a 5-month period from May 1 to October 1, 2017, during which eye and body occupational radiation doses were measured throughout all consecutive procedures that took place in this time frame as primary	Five (56%) radiologists exceeded the 20 mSv annual eye lens dose limit. This study shows that radiation doses to the eye lens of full-time IRs frequently exceed the recommended threshold limit and can even reach deterministic values in terms of cataractogenesis without adequate eye lens protection	eye lens doses in full-time interventional interventionists are likely to exceed the ICRP’s latest dose limit of 20 mSv per year and lead to deterministic eye lens damage.

			Correlations between eye lens and neck TLD doses were assessed	operators as well as assistants		
5. Amis (2011)	Editorial	Level IV Guidelines				Combining various types of shielding results in dramatic dose reduction for the operator (and other nearby personnel, such as the anesthesiologist) and that this method should be the norm rather than the exception. anesthesiologists follow the practice of radiologists and wear leaded glasses to prevent cataracts when monitoring patients during neurointerventional cases.

6. Boice, Dauer, Kase, Mettler, Vetter (2020)	Review	Level IV Consensus/ position statements				Paralleling the advancements in medicine and patient survival is also the adverse consequences of radiation exposure to medical professionals. Radiation protection guidance has evolved and continues to do so today. Radiation protection needs to combine new knowledge of potential health risks and provide guidance to avoid inadvertent exposure without curtailing patient benefits.

7. Anastasian, Strozyk, Meyers, Wang, Berman (2011)	Scatter radiation during interventional radiology procedures can produce cataracts in participating medical personnel. Standard safety equipment for the radiologist includes eye protection. The typical configuration of fluoroscopy equipment directs radiation scatter away from the radiologist and toward the anesthesiologist. This study analyzed facial radiation exposure of the anesthesiologist during interventional neuroradiology procedures.	Level I Quantitative Study	Radiation exposure to the forehead of the anesthesiologist and radiologist was measured during 31 adult neuroradiologic procedures involving the head or neck. Variables hypothesized to affect anesthesiologist exposure were recorded for each procedure. These included total radiation emitted by fluoroscopic equipment, radiologist exposure, number of pharmacologic interventions performed by the anesthesiologist, and other variables.	Studied radiation exposure at the forehead of the radiologist and anesthesiologist in 31 adult neuroradiologic procedures involving the head and neck, performed at Columbia University Medical Center, New York, New York, from January 26, 2009, to October 30, 2009	Radiation exposure to the anesthesiologist's face averaged 6.5 - 5.4 MSv per interventional procedure. This exposure was more than 6-fold greater than for noninterventional angiographic procedures and averaged more than 3-fold the exposure of the radiologist	Anesthesiologists who spend significant time in neurointerventional radiology suites may have ocular radiation exposure approaching that of a radiologist. To ensure parity with safety standards adopted by radiologists, these anesthesiologists should wear protective eyewear.
8. Arii, Uchino, Kubo, Kiyama, Uezono (2015)	Medical radiation exposure increases the likelihood of cataract formation. A personal dosimeter was attached to the left temple of anesthetists during endovascular aortic aneurysm repairs and interventional neuroradiology procedures.	Level I Quantitative Study	A personal dosimeter was taped to the left temple (patient-facing) of each anesthetist. Dosimeter absorption was assumed to represent ocular radiation exposure. Anesthesia was administered at the discretion of each anesthetist, who was instructed to maintain their routine safety	A personal dosimeter was attached to the left temple of 77 anesthetists during 45 endovascular aortic aneurysm repairs and 32 interventional neuroradiology procedures. Each procedure, we measured procedural duration, total fluoroscopic radiation emission and the	median total dose of radiation emitted during fluoroscopy was three times higher during interventional neuroradiology, and four times higher during EVAR procedures, ocular radiation exposure, during EVAR is accounted for by closer proximity of the anesthetist during the interruptions to mechanical ventilation that are an intrinsic part of the EVAR procedure	anesthetists who regularly administer for EVAR and interventional neuroradiology need to remain aware of the risk of occupational and ocular radiation exposure and take appropriate steps to minimize risk. Risk reduction involves limiting dose exposure, increasing distance from the source, wearing suitably

			measures (lead apron (lead equivalent 0.35 mmPb), thyroid shield	number of interruptions of mechanical ventilation during angiography.		protective clothing, and using shields.
9. Khamtuikrua & Suksompong (2020)	The objective of this study was to examine awareness about radiation hazards and knowledge about protection methods among the anesthesia personnel and surgical subspecialists of a quaternary care academic center.	Level III Qualitative Study	A validated questionnaire was completed by anesthetic personnel and surgical specialists. It consisted of questions that assessed awareness about radiation hazards. 15 multiple- choice questions assessed knowledge about radiation; including radiation protection, annual radiation dose, personal protection equipment, safe distance from an X-ray machine, and susceptible organs	This questionnaire-based cross-sectional study was conducted among the anesthesia personnel and surgical subspecialists of a quaternary care academic center in Bangkok, Thailand. A total of 270 potential participants were emailed and invited to respond to an online questionnaire, and the response rate was 79.3%.	78.5% of the participants of this study wore a thyroid shield, but only 31.3% of them wore lead goggles. A low rate of compliance about the wearing of lead goggles was found. 96.7% of the participants of this study considered radiation to be very harmful or harmful. However, only 86.4% and 78.5% of them always wore a lead apron and thyroid shield in their work environments	there is a need to improve anesthetic personnel and surgical subspecialists' knowledge about radiation protection, especially regarding the use of lead goggles and harmful doses of radiation. There is a relative lack of knowledge about radiation hazards and protection among anesthesia personnel and surgical subspecialists. Therefore, continuing medical education on radiation hazards and protection must be mandated.

10. Bera, Gellie, Jamet, Entine, Michel (2018)	To evaluate the eye-lens radiation exposure of workers during medical interventional procedures and surgery in a military hospital	Level I Quantitative Study	The eye lens dosemeters were positioned on the temple close to the right or left eye, on the side of the head receiving the highest dose The measured radiation exposure represented the exposure in a normal working schedule over a 3-month period and this cumulative eye lens dose was extrapolated to a 1-year period.	Medical workers in surgery and medical IP in a military hospital were prospectively included from January to March 2017. A total of 90 workers including cardiologists, radiologists and surgeons, gastroenterologists were asked to wear an eye lens dosimeter for 3 months.	If the use of leaded glasses is not considered, studies demonstrate that the annual ICRP's dose limit can largely be exceeded in the spectrum of cardiology and therapeutic radiology IP particularly for the main operator several years of practice, without eye protection, the dose may exceed the new ICRP lifetime eye threshold of 500 mSv.	eye lens dose monitoring of workers during IP appears to be necessary, especially in cardiology training workers exposed to ionizing radiations is strongly recommended. The use of personal radiation protection equipment is also highly encouraged .
11. Haga, Chida, Kimura, Yamanda, Sota, Abe, Kaga, Meguro, Zuguchi, (2020)	The purpose of this study was to clarify the current occupational eye dose of bronchoscopy staff conducting fluoroscopically guided procedures.	Level I Quantitative Study	We measured the occupational eye doses (3-mm-dose equivalent, Hp(3)) of bronchoscopy staff (physicians and nurses) over a 6-month period. The eye doses of eight physicians and three nurses were recorded using a direct eye dosimeter. We also estimated eye doses using personal dosimeters worn at the neck	This study was conducted at Sendai-Kosei Hospital over a 6-month period, from April to September 2018, during which 100 diagnostic bronchoscopy procedures were performed The occupational radiation exposure of the eyes (eye dose) of eight physicians and three nurses during bronchoscopy was measured using a dosimeter,	The occupational eye doses in bronchoscopy staff (physicians and nurses) are high, particularly in physicians, as well as in cardiac interventional radiology staff. The eye dose in bronchoscopy physicians may exceed the new regulatory dose limit. Therefore, we recommend that bronchoscopy staff, should wear lead glasses during procedures.	The new lens dose limit, 20 mSv/year, may be exceeded among bronchoscopy staff, especially physicians. Hence, the occupational eye dose of bronchoscopy staff should be monitored. To reduce the occupational eye dose, we recommend that staff performing fluoroscopically guided bronchoscopy wear lead glasses.

12. **Khan, Lacasse, Khan, Murphy (2017)**	This review explains the pathogenesis of radiation-induced cataracts, exploring emerging evidence regarding their development. It also explores monitoring and protection measures available to protect against radiation induced conditions.	Level V Literature Review				To achieve the greatest reduction in dose exposure, room-shielding equipment must be combined with personal protective equipment; protective aprons, thyroid shields, gloves, and eyewear. To prevent the detrimental effects of occupational radiation on health workers, there must be a strict worldwide application of the recent lower radiation threshold guidelines, a more effective means of monitoring radiation exposure, and consistent use of appropriate radiation-protection strategies.
13. Vaes B, Van Keer K, Struelens L, et al. **(2017)**	This prospective study investigated eye lens dosimetry in anesthesiology practice during a routine year of professional activity.	Level I Quantitative Study	anesthesiologists were asked to wear an eye lens dosimeter during a period of 1 month. All procedure types were recorded including orthopedic surgery, endovascular surgery, neurointerventional angiographic procedures, also surgical procedures without radiation exposure.	Anesthesiologists were recruited between January 2014 and December 2014, wore a dosimeter for one month.	eye lens doses during neuro-embolization, cardiac ablation and vertebro/kyphoplasty procedures resulted in higher doses compared to others A higher exposure can occur when the anesthesiologist is positioned in close proximity to the patient during the procedure. This is often the case in hemodynamically unstable patients and when ventilation stops (apnea) are requested frequently during the intervention	anesthesiologists who regularly work in a radiological environment need to be aware of how to reduce occupational exposure. Keeping distance and the availability of adequately protective equipment including protection shields, apron, thyroid shield, and leaded eye wear are the most efficient ones.

14. Barnard, Ainsbury, Quinlan, Bouffler (2016)	This review examines the evidence for radiation dose limits to the eye in medical ocupational exposure. This report draws conclusions on the evidence of cataract development in occupational exposure of medical workers.	Level V Literature Review				recent literature suggests that medical radiation workers may develop cataracts, as a result of occupational exposures. Furthermore, the data in this review indicate that eye lens doses to individuals who are occupationally exposed in the medical sector may in some cases currently exceed 20 mSv annually, especially for interventional radiologists and cardiologists.
15. Lian, Xiao, Ji, et al. (2015)	The aim of this study was to assess the risk of cataract following protracted low doses of radiation exposure among industry radiographers and comparison groups of unexposed workers.	Level I Quantitative Study	A cohort of industry radiographers and unexposed workers in China was followed up for 12 years. The lens doses were based on individual monitoring. Presence of cataract was assessed clinically based on lens photographs using the Lens Opacities Classification System III	The cohort consisted of 1753 industrial radiographers and 2500 control workers registered at the Kelamayi Centers for Disease Control (CDC) of Xinjiang Autonomous Region, China, between 1 January 1995 and 30 December 2000.	Industry radiographers were significantly more likely than unexposed workers to develop cortical cataracts However, the risk decreased for regular users of shielded enclosures, lead eyeglasses and lead aprons.	low level radiation exposure increased the risk of cortical and PSC cataracts, with no apparent threshold level, a finding that challenged the current ICRP statement that considers the threshold dose for the ocular lens risk of lens radiation injuries could be reduced by regular use of radiation protection tools, including shielded enclosures, lead eyeglass enclosures, lead eyeglass and lead aprons.

16. **Dauer, Ainsbury, Dynlacht, et al.** **(2017)**	This review summarizes the conclusions and recommendations on the new National Council on Radiaiton Protection and Measurements (NCRP) guidance on radiation dose limit for the eye	Level V Review				In fluoroscopically guided interventional or cardiac procedures, the use of adequate eye protection is clearly a necessity, especially for high-volume practices Evidence suggests lens damage could occur at lower doses than previously considered and the annual lens dose should be reduced from 150mSv to 50mGy
17. **Miller, Schueler, Balter (2012)**	ICRP recommends lowering the dose limit for the lens of the eye. This recommendation should underscore the importance of proper eye protection.	Level IV Recommendations / Guidelines				Advances in our understanding of the risk for radiation-induced cataract have led to a dramatic decrease in the recommended dose limit or the lens of the eye. Eye protection should be used routinely.

18. Attigah, Oikonomou, Hinz, et al. (2016)	The purpose of this study was to evaluate the radiation exposure of vascular surgeons' eye lens and fingers during complex endovascular procedures in modern hybrid operating rooms.	Level II Mixed Method Prospective, nonrandomized multicenter study design.	endovascular procedures in a hybrid operating room. The dose-area product (DAP), fluoroscopy time, operating time, and amount of contrast dye were measured. For radiation dose recordings, single-use dosimeters were attached at eye level and to the ring finger of the hand next to the radiation field of the operator for each endovascular procedure.	Between March 2012 and July 2013, 171 consecutive patients underwent an endovascular procedure in two vascular centers, in Nuremberg, Germany.	A dosimeter was also placed at the working place of anesthesia, approximately 2.5 m away from the radiation source. The recording over 110 days showed a dose of 3.1 mSv. This emphasizes the need for protection of the whole room personnel. In the case of anesthesiologists, this is best accomplished by the means of moveable lead walls in addition to lead aprons. Because there is no clear evidence so far whether radiation injury to the eye lens is deterministic rather than stochastic, maximum eye protection should be implemented with care.	Radiation protection is a serious issue of increasing importance for interventionalists such as vascular surgeons, because most complex endovascular procedures impart measurable radiation doses to the eye lens In this study the threshold of 20 mSv would be reached in approximately 1400 minutes of fluoroscopy time per year. .
19. Cornacchia, Errico, La Tegola, et al (2019)	explore the implications of dose limit for occupational radiation protection in the context of medical occupational radiation exposures. new ICRP recommendations on reduction in the dose limit for the lens of the eye for occupational exposures.	Level III Systematic Review	Different dose-monitoring procedures and devices were considered. Occupational eye lens doses reported by previous studies were analyzed, mainly considering workers involved in interventional procedures with X-rays. The current status of eye lens radiation protection and the main methods for dose reduction were investigated		The analyzed studies demonstrate that exposed workers involved in interventional procedures using X-rays could potentially exceed the eye lens equivalent dose of 20 mSv/ year if a radiation protection environment is not properly structured. As far as occupational eye lens dose reduction is concerned, the three well-known factors time, distance and shielding must be kept in mind.	The evaluation of the occupational eye lens dose is essential to establish which method of personal dose monitoring should be preferred. Furthermore, education and training about the right use of personal protective equipment are important for medical staff working with ionizing radiation.

20. Ciraj-Bjelac, Carinou, Ferrari, Gingaume, Merce, O'Connor (2016)	The objective of this work is to review eye lens dose levels in clinical practice that may occur from the use of ionizing radiation The practical implementation of monitoring eye lens doses and the use of adequate protective equipment remains a challenge. The use of lead glasses with a good fit to the face, appropriate lateral coverage, and/or ceiling-suspended screens is recommended in workplaces with potential high eye lens doses.	Level IV Guidelines				The eye lens is more sensitive to radiation than previously understood. The ICRP has set a threshold dose of 0.5Gy for radiation induced cataracts, but research suggests there is no threshold dose, but additive dose may predispose to radiation induced cataracts. Personal protective equipment should be used routinely; lead glasses with a good fit to the face, good lateral coverage, and/or ceiling-suspended screens should be used to optimize eye dose

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